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A review of energy planning practices of members of the Economic Community of West African States

N.C. Lee *, V.M.S. Leal

IDMEC—Institute of Mechanical Engineering, University of Porto—Faculty of Engineering, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

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ABSTRACT

The aim of this study is to provide a systematic review of the energy planning (EP) activities being conducted in the Economic Community of West African States (ECOWAS). Of particular interest is the establishment of an understanding of current practices. A matrix of evaluation of literature was developed and applied, to find out who is active in EP, the purposes of EP, how energy demand is considered, the scope of the EP activity, and the specificity of indicators used in the ECOWAS region. Energy planning documents were discovered for ten ECOWAS members and the West African Power Pool (WAPP). Electrical systems planning documents were the most common. A set of common *fundamental* objectives for the EP activities was found. Disconnections were found between EP Objectives and the Attributes used in the EP activities. Monitoring and verification activities as part of the plans were absent from all of the EP documents. While few similarities were found through the comparison of indicators/attributes used in the EP documents of ECOWAS and those used in more developed countries, in contrast the analysis found similarity between the EP objectives set by the region and those of developed countries.

Contents

Abbreviations: DSM, Demand Side Management; ECOWAS, Economic Community of West African States; ECREEE, ECOWAS Regional Centre for Renewable Energy and Energy Efficiency; EP, Energy Planning; NFI, National Focal Institute; UN, United Nations; UNDP, United Nations Development Programme; WAPP, West African Power Pool

* Corresponding author. Tel.: +351 22 041 3483.
E-mail addresses: nathan.lee@fe.up.pt (N.C. Lee), vleal@fe.up.pt (V.M.S. Leal).

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1. Introduction

Access to modern energy services has been acknowledged as a key ingredient to development efforts, vital to economic and human development as well as to environmental protection [1–7]. Access to modern energy is available to only approximately 17% of the Sub-Saharan African population, a value which differs between countries as well as between urban and rural populations [8]. In the Economic Community of West African States (ECOWAS) region, ambitious targets have been set: to reach 100% access to modern cooking fuels, 60% access to energy for productive purposes, and 66% access to individual electricity supplies by 2015 [3]. These ambitious goals call for EP practices and models that are adequate to the geographic context.

The energy sectors of developing[1] countries have intrinsic differences from those of more developed countries, thus likely implying that EP activities within these countries require models or methodologies constructed for these specificities. One way of checking the existence of such specificities would be a structured review of the EP activities at the regional (multiple countries), national, and local scale within the ECOWAS region, which to the authors' best knowledge has not been performed previously.

The aim of this work therefore is twofold. First it establishes a characterization and understanding of current EP practices in the ECOWAS region, in terms of who are the promoters and technical analysis actors, what is the purpose of the EP activities, how energy demand is considered in the EP activity, and what is the scope of the EP activity. Secondly it draws on the understanding of EP practices gained in the first phase to develop recommendations which may aid in developing effective future EP activities in the support of policy development.

A depiction of the ECOWAS region follows this section (Section 2) with a general description of the socio-economic situation. Section 3 provides the methodologies used for the EP document search, and the matrix of evaluation. The results are then presented in Section 4 following the format of the questions asked in the matrix of evaluation. Section 5 presents a comparison of indicators/attributes used in the EP documents of ECOWAS versus a list of energy based sustainability indicators for more developed countries. Finally, Section 6 presents the key conclusions of the work.

[1] Definitions for developed and developing countries have been provided by various international organizations based on classification needs of the organization. The World Bank classifies according to Gross National Income (GNI) per capita. Low and Lower-middle income countries have GNIs per capita of $1005 and $3975 respectively [9]. The International Monetary Fund (IMF) refers to emerging and developing countries, a more flexible classification by per capita income, export diversification, and degree of integration into the world financial system [10,11]. The United Nations refers to developing countries below the 75th percentile in the Human Development Index (HDI) distribution. The HDI is a composite index considering GNI, life-expectancy at birth, and measures of actual and expected years of schooling [12]. Distinction is often made between members of the Organization for Economic Co-Operation and Development (OECD). For a further discussion of definitions and evaluation methods of country development levels see Nielsen [10].

2. The ECOWAS

The ECOWAS was selected as a way to narrow the focus of the analysis, while maintaining a significant sample of developing countries. The member states, although a diverse group of nations, face many of the challenges to economic and human development common to other developing countries.

2.1. Socio-economic situation

ECOWAS consists of 15 countries of the Sub-Saharan West African region presented in Fig. 1. The 15 member states are Cape Verde, Senegal, The Gambia, Mali, Niger, Nigeria, Togo, Benin, Sierra Leone, Ivory Coast, Liberia, Burkina Faso, Guinea-Bissau, Guinea, and Ghana. The ECOWAS region covers roughly 17% of the area of the African continent. While the states are members of a single community and face many similar challenges, they represent a very diverse group, and diversity exists between the members and within the borders of the individual countries. The largest states, Mali and Niger, have areas over 1.2 million km^2, while The Gambia and Cape Verde, cover 10.6 thousand km^2 and 4000 km^2 respectively [13]. There is one island nation, Cape Verde, and 3 landlocked states, Mali, Niger, and Burkina Faso.

In 2010 the ECOWAS population was 301 million, and is forecasted to reach 342 million by 2015. Nigeria, the most populated state, had a population of 158 million in 2010. Ghana has the 2nd largest population, 24 million, while the remaining states have populations between 1 and 16 million. Cape Verde has a population of fewer than 500,000 [15].

13 of the 15 member states were classified as Low Human Development by the United Nations Development Programme (UNDP), with the exception of Cape Verde and Ghana, which were classified as Medium Human Development [12]. All the members were classified as Least Developed Countries, except Cape Verde, Ghana, and Nigeria, by the United Nations, while the Ivory Coast was not included [16]. All the members were classified by the World Bank as part of the low income group, except for Cape Verde in the lower middle income group [17]. The ECOWAS countries were classified by the IMF as Emerging and Developing Economies, and 13 of them held the status of Heavily Indebted Poor Countries [18].

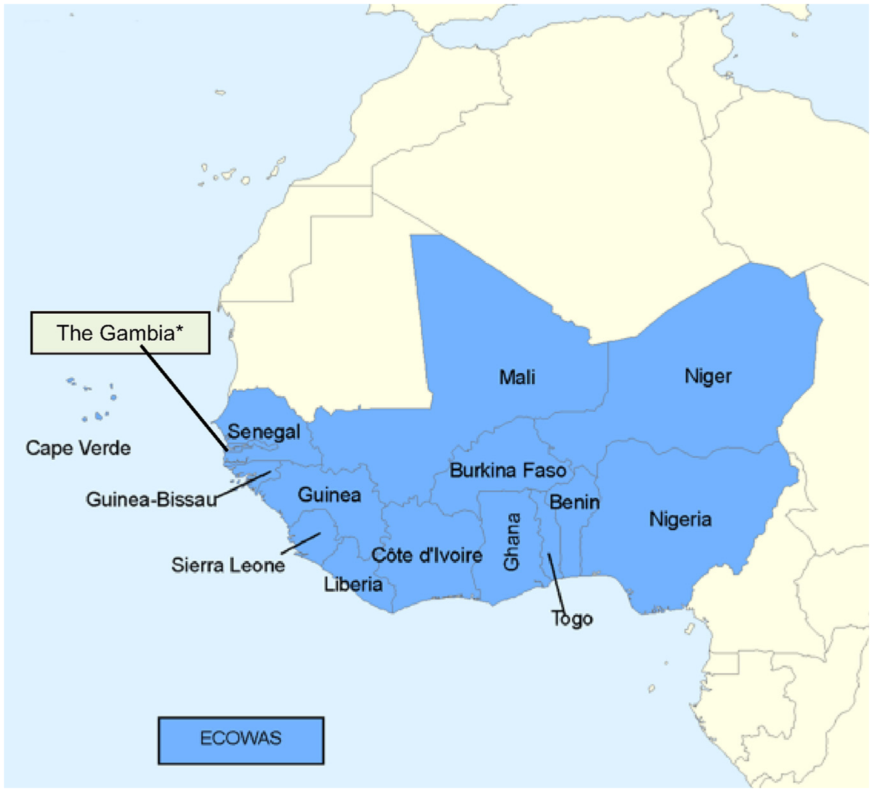


Fig. 1. Map of ECOWAS region [14].*Country identifier added to graphic by authors.

Table 1
Matrix of evaluation.

1 Who is active in EP?	2 What is the purpose of EP activities?	3 How is energy demand considered?	4 What is the scope of the EP activities?
1.1 Which ECOWAS member states have EP documents?	2.1 What types of EP activities are being conducted?	3.1 How is energy demand forecasted?	4.1 What modeling tools are used?
1.2 What actors are involved in the planning activities?	2.2 What are the objectives of the EP documents?	3.2 What factors are considered in the demand forecast?	4.2 Which primary energy sources and final energy carriers are considered?
	2.3 What attributes are used in the EP process?	3.3 Are distinctions made between Urban and Rural energy demands?	4.3 Are environmental consequences of energy demand forecasts quantified?
	2.4 What indicators are used for measurement and verification?	3.4 How long are the planning horizons considered?	
		3.5 How many scenarios are considered?	
		3.6 How many alternatives are presented in demand forecasts?	
		3.7 Are considerations of energy demand side management measures made?	

3. Methodology

3.1. Document gathering

It is important to point out that EP documents were considered to be those which required energy sector actors to make assumptions about future scenarios and to develop quantified energy demand forecasts. EP documents provide the data and information necessary for the development of Energy Policies and Program Specific documents which set the vision and establish programs to achieve this vision respectively. Energy Policies lay out a desired vision for energy demand and supply and the strategies which will aid in the achievement of this vision. Energy Program Specific documents are those which focus on specific energy resources or technologies and the implementation of specific projects. The current review only includes EP documents as defined above, but not Policy or Program Specific documents, as the first are too general to provide insights into EP practices and the latter are too specific and lack representativeness of the practices.

A comprehensive online search was conducted to gather EP documents from all ECOWAS members for multi-state regions, countries, or cities or municipalities available from sources which included governments, government institutions, international organizations and academic research journals. After searching these sources and following references cited in the works recovered, a point was reached when no new documents were recoverable. This collection process gathered 56 documents. From this set, general policy or program specific documents were eliminated and only EP documents, as defined previously, were considered for analysis, resulting in 14 documents.

Limitations exist to an online document search, as not all EP documents are available online from government, institution, and other organizations for countries in the ECOWAS region. To bolster the search effort an inquiry was conducted in cooperation with the ECOWAS Center for Energy Efficiency and Renewable Energy

Table 2
EP documents and type.

Document number	Country	Document name		Document type			
				Energy Master Plan	Electric System Plan	Environmental Protection Plan	Basic Energy Services Plan
D1	Cape Verde	National Energy Plan	[20]	√			
D2	Ghana	Strategic National Energy Plan	[21]	√			
D3	Benin	Strategy for the Supply of Energy Necessary for the Achievement of the MDGs	[22]				√
D4	The Gambia	Master Plan for Renewable Energy based Electricity Generation in The Gambia	[23]		√		
D5	Nigeria	Assessment of Energy Options and Strategies for Nigeria: Energy Demand, Supply and Environmental Analysis for Sustainable Energy Development (2000-2030).	[24]		√		
D6	Senegal	Economics of Greenhouse Gas Emissions	[25]			√	
D7	Nigeria	Electricity Demand Forecasting in Nigeria using Time Series Model.	[26]		√		
D8	Liberia	Simplified Power System Master Plan - A Primer for Decision making	[27]		√		
D9	Togo	Support Program for the Control of Traditional Energies and the Promotion of Renewable Energies in Togo	[28]			√	
D10	Sierra Leone	The Sierra Leone Energy Sector: Prospects and Challenges	[29]		√		
D11	Ghana	Assessing Policy Options for Increasing the Use of Renewable Energy for Sustainable Development: Modelling Energy Scenarios for Ghana	[30]		√		
D12	WAPP[a]	Update of the Revised Master Plan for the Generation and Transmission of Electricity	[31]		√		
D13	Nigeria	Renewable Energy Master Plan	[32]	√			
D14	Cape Verde	Renewable Energy Plan of Cape Verde	[33]		√		
D15	Ivory Coast	Strategic Development Plan 2011-2030: Electricity and New and Renewable Energies	[34]		√		
Count				3	9	2	1

[a] West African Power Pool (WAPP).

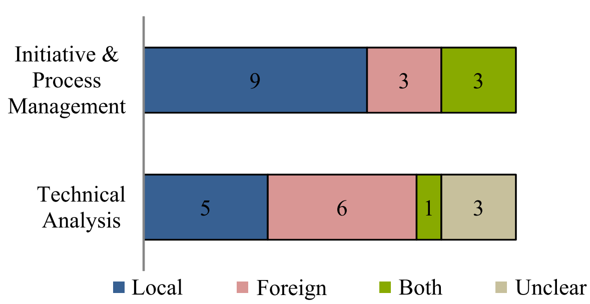


Fig. 2. Actors involved in EP activity.

(ECREEE). Fifteen official National Focal Institute (NFI) contacts of the ECREEE, representing each of the ECOWAS members were asked about their knowledge of existing national, city or municipality, and other EP documents for their country as well as their ability to provide the documents for this review. The inquiry, translated into the respective official country languages of the region, was provided to the NFI contacts through the ECREEE.

Of the 15 NFI contacts contacted a total of 6 responses were received within 29 weeks after having been sent. The inquiry process provided information on an additional 22 documents. From these only one document D15 (presented with results) which was considered a planning document, had not already been recovered in the online search. It was added to the list of EP documents to be reviewed.

The 15 EP documents recovered are presented with the results in Section 4 (Table 2). The document numbers included are used throughout this report to avoid confusion. No preferential order was given to documents in the list. Both the presence of as well as the absence of an EP document are important to note as the absence of an EP document for a country speaks to the presence of EP activities in a country and the capacity to provide input to energy policies.

3.2. *Matrix of evaluation*

A matrix of evaluation was constructed to provide a systematic methodology of evaluation of the documents (Table 1). Four main questions provided a structure for the evaluation.

The first question asks who was active in the EP activities. The aim of this first question is to establish an understanding of which ECOWAS members have EP documents as well as what actors, both foreign and local, contributed to the activity together with the nature of their contribution, i.e. technical support or management.

The second question addresses the purpose of the EP activity. This provides an understanding of what type of activities are being conducted, e.g. environmentally focused, power system focused, or other. In addition, this question allows for characterization of the objectives which were set for the EP activity, the attributes used to pre-assess planning alternatives, and the indicators presented for measurement and verification activities.

The method in which energy demands are evaluated is explored in the third question, exploring the data requirements, geographical considerations, planning horizons, the scenarios constructed, and the planning alternatives considered.

The final question explores the scope of the activity with a look at the available planning-assisting models and tools, e.g. models and methodologies cited in the works. It also characterizes the primary energy sources considered in the works as well as the secondary/final energy carriers. Also a review of which environmental consequences were quantified as part of the planning alternatives considered was conducted.

The level of specificity of energy based indicators employed in the documents is also explored. Two sets of energy sustainability indicators for local EP in more developed countries, presented by Neves and Leal [19], were used for juxtaposition with those found in EP documents of ECOWAS.

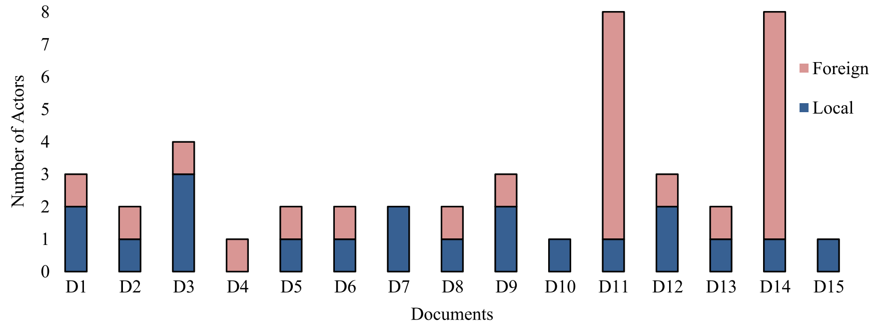


Fig. 3. Number of actors involved per document.

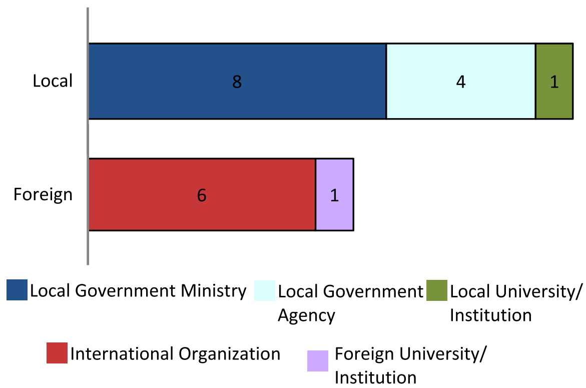


Fig. 4. Breakdown of Initiative and Process Management Actors.

4. Results

4.1. Who is active in EP?

4.1.1. Which ECOWAS member states have EP documents?

Of the 15 member states, EP documents within the criteria defined, i.e. having quantified demand forecasts were recovered for 10 countries and the West African Power Pool (WAPP). Table 2 presents the EP documents types recovered. Three documents were found representing Nigeria, and two documents were encountered for Cape Verde and Ghana.

4.1.2. What actors are involved in the EP process?

A breakdown of the actors involved in the initiative and process management, and in the technical analysis is presented in Fig. 2. Here "local" refers to those based within the country.

Initiative and process management actors were predominantly local actors, where 9 of 15 documents had only local actors and 3 had both local and foreign initiative. The Technical analysis effort was closely divided between foreign and local actor involvement, in 6 and 5 of the documents respectively. The technical analysis effort, coming either from foreign or local actors, was considered unclear in 3 of the documents, D6, D9, and D10.

An assessment of the number of actors involved in the individual documents is presented in Fig. 3. The majority, 12 of the 15 documents included the involvement of more than one actor. Collaborations between local and foreign actors were found in 11 of the 15 documents.

Two of the documents reviewed were academic documents, D4 and D7. D4 is a foreign doctoral student's thesis focused on Gambia's electrical energy system. D7, an academic article, had authors in two separate university departments, counted as two local actors in Nigeria. D11, is a United Nations Energy (UN Energy) study for Ghana which included a collaboration of separate international agencies. D14 is an EP document from Cape Verde with multiple foreign actors.

A breakdown of foreign and local actors involved in the initiative and process management is presented in Fig. 4. The most common local actors found were government ministries, government agencies, e.g. national energy commissions and national statistics institutions. The most common foreign contribution was from international organizations, e.g. The United Nations (UN).

A disaggregation of the initiative and process management actors by document is shown in Fig. 5. Local government ministries were involved in 8 of the 15 documents and government agencies in 4 of the documents. Multiple government ministries were also involved in 3 of the documents. Here collaborations between local government ministries or agencies and international organizations were found in 4 of the 15 documents.

The breakdown of technical analysis actors is presented in Fig. 6. The technical effort was unclear in 3 of the documents D6, D9, and D10, and these are not included in Fig. 6. Local government ministries were involved in 2 of the documents, and government agencies were found in 3 of the 15 documents. Foreign contribution from consultant/companies was found in 4 of the 15 documents while both international organizations and foreign universities were found in 2 of the 15 documents.

The technical analysis actor type by document is presented in Fig. 7. Here foreign consultant/companies were involved in 4 of the 15 documents, and government agencies were involved in 3 of the documents. Document D11 was a collaborative effort from the UN Energy involving multiple actors such as the International Atomic Energy Agency (IAEA), Department of Economic and Social Affairs (DESA), Food and Agriculture Organization (FAO), United Nations Environment Programme (UNEP), United Nations Industrial Development Organization (UNIDO), and the World Bank. The actors involved in D14 also included multiple foreign consultants.

4.2. What is the purpose of EP activities?

4.2.1. What types of EP activities are being conducted?

The EP document types recovered can be characterized within 4 categories. *Energy Master Plans* include forecasts of multiple energy carriers, demand sectors, end-uses, and possibly primary energy sources for the country. *Electrical Systems Plans* specifically consider electrical energy systems, which may include multiple demand sectors, end-uses, and primary energy sources or be specific to renewable energy sources for electricity generation. *Environmental Protection Plans* have environmental planning focuses, and include energy demand projections for this end. *Basic Energy Services Plans* focus on the provision of energy services for development, and more closely resemble policy documents outlining government goals for energy access and include energy demand forecasts. This final category differs from *Energy Master Plans* which are more all-encompassing and present forecasts for multiple energy carriers, sectors, end-uses and primary energy sources.

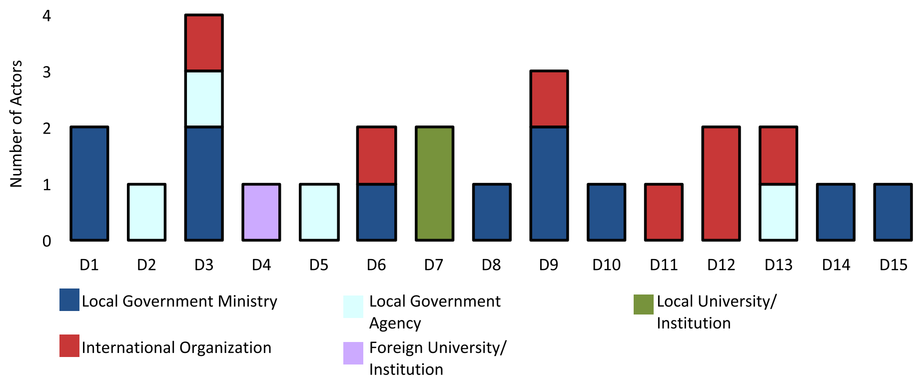


Fig. 5. Initiative and Process Management Actors per Document.

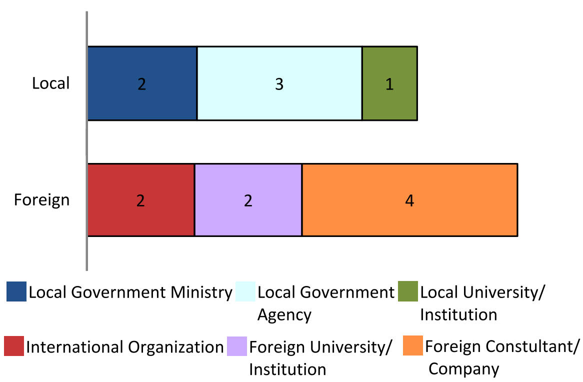


Fig. 6. Breakdown of Technical Analysis Actors.

Table 2 presents the EP document types recovered. Here it is seen that 9 of the 15 documents were *Electrical System Plans*, the most common EP document type. *Energy Master Plans* were the second most common, followed by *Environmental Protection Plans*. There was one *Basic Energy Services Plan*.

4.2.2. *What objectives are set for the EP activity?*

The EP activity, like any complex problem, should be structured around a number of objectives which set the overarching purposes for which the activity is undertaken. These objectives should then be reflected throughout the EP process.

These objectives include both *fundamental* and *means* objectives. Following the Value Focused Thinking method from Keeney [35], *Fundamental* objectives are those that are both essential and controllable objectives, while *means* objectives are those which are important due to their implications for other higher level objectives. Identification of *fundamental* and *means* objectives lies in the answer to the question “Why is this objective important?” Keeney specified two possible answers, the first being that the objective describes a core reason for interest in the problem, meaning it is a potential *fundamental* objective. On the other hand, if the answer to the question brings an additional objective to light it is a *means* objective.

Structuring of objectives in a decision problem as described by Keeney [35] aids in defining the objectives, relating them to one another, and relating them to yet to be identified objectives. This is typically to be done within a specific decision context at the start of the EP activity. For this work, however, an effort is made to structure the *fundamental* objectives, in order to identify the objectives stated within a common frame of reference.

A total of 49 objectives were identified from the review of the EP documents. The complete list of these objectives is presented in Appendix A.

To establish a list of fundamental objectives it was necessary to identify the *fundamental* objectives which were implicitly referred to through the *means* objectives explicitly stated. This process, further detailed in Appendix A, led to a list of *fundamental* objectives which fall into themes identified here as Social, Economic, and Environmental which were either Energy sector specific or Non-energy sector specific. These objectives, filtered down to a set of 13 *fundamental* objectives, explicitly (E) or Implicitly (I) stated, and one category for Unclear Objectives are presented in Table 3. Table 3 presents a total of 46 fundamental objectives as it was found that documents implicitly or explicitly repeated the same objective, while in other cases stated objectives implicitly referred to multiple fundamental objectives.

In Table 3 it is seen that the most commonly stated EP objectives are to increase access to modern energy (S1), to increase security of energy supply (EC1), to increase system reliability respectively (EC2), and to minimize environmental impacts attributed to the energy sector (EN1). Economic objectives both within the energy sector and the non-energy sector were the most common with 18 references to economic objectives in the documents. Social objectives were the second most commonly stated with 15. Thirteen environmentally themed objectives were stated.

Nine of the fundamental objectives identified for this work were explicitly stated and the remaining 34 were implicitly referred to in the EP documents.

It could be of some surprise that there appears to be little reference to objectives related to costs of investment, operation or maintenance. While cost-related objectives were not explicitly or implicitly referred to in the documents as part of their EP objectives, there were some references to cost attributes, despite not being clearly linked to objectives of “minimizing costs.” The socially themed objective, S3 (“improve ability to provide affordable of energy”) which references the costs of energy for end users was stated in 3 of the documents (D4, D12, and D15).

The use of objectives falling into different theme types was also examined. Of the 15 documents reviewed, 10 included more than one objective, and eight stated objectives falling into more than one theme type. Seven of the EP activities included objectives falling into all three themes of Social, Economic and Environmental objectives. The objectives of D5 were considered unclear.

4.2.3. *What attributes are employed?*

Attributes are quantifiable parameters used to assess the current state and to pre-assess the achievement of Objectives in various alternatives, and are important in ensuring that Objectives are linked into the actual EP process.

The attributes found or inferred were disaggregated by their respective objective theme as well as the documents which consider them. Two types of attributes were found in the

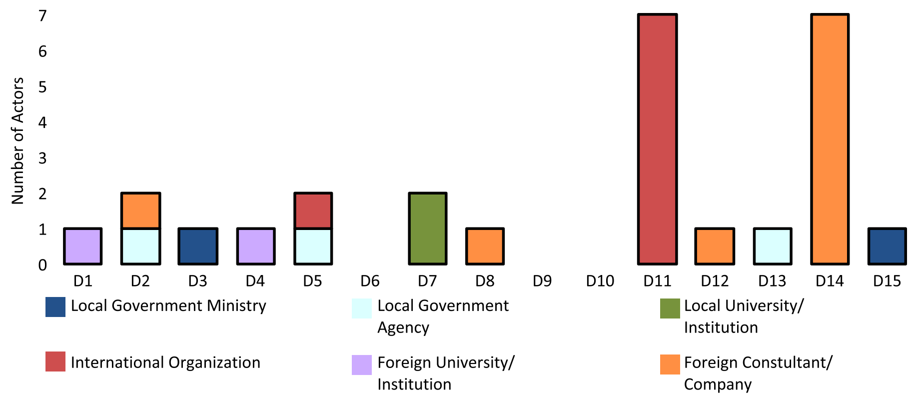


Fig. 7. Technical Analysis Actors per Document.

Table 3
Fundamental objectives.

Theme	Objective	Code	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	Count
Energy Sector																		
Social	Increase access to modern energy	S1		I	I						I	E		I	I			6
	Improve governance of the energy sector	S2		E							E	E						3
	Improve ability to provide affordable energy	S3				E								I			E	3
Economic	Increase security of energy supply	Ec1	I	I							I		I		I	I		6
	Increase system reliability	Ec2		I	I	E			I	I		E					I	7
Environmental	Minimize environmental impacts attributed to the energy sector	En1	I	I		I					I	E			I	I	I	8
	Minimize adverse health impacts attributed to the energy sector	En2									I	E			I			3
	Minimize climate change impacts attributed to the energy sector	En3						I										1
Non-Energy Sector																		
Social	Improve quality of life of populations	S4	I												I			2
	Decrease rural emigration	S5													I			1
Economic	Increase economic development	Ec3	E	I											E		I	4
	Increase economic integration of West African States	Ec4		I														1
Unclear	Document with unclear objective	Un					–											1

documents; the first can be described as *diagnosis attributes* used to provide an understanding of a current situation or projection, but not used to compare alternatives for the future. The second type was *decision process attributes,* used in the process of comparing alternatives for the future. Of the initial list of 132 attributes, the most common attribute type was that of *diagnosis attributes*, with 79 counts, while the remaining 53 attributes were *decision process attributes*. It is of note that of the latter category, 27 were used within a single document, D6.

The initial list of 132 attributes was filtered down to a list of 63 attributes through a process of eliminating common attributes. This resulting list of attributes is presented in Table 4, together with the specific objectives to which they were determined to be linked to in the EP document as well as the documents in which they were used. The objectives are listed by the codes presented previously in Table 3.

Not all of the objectives could be clearly tied to an attribute used within the EP activity, namely objectives S2, S5, Ec3, and Ec4. Also 11 attributes could not clearly be linked to an objective stated in the corresponding document. A number of the objectives were linked to multiple different attributes in different EP documents. The reverse was also found to be true, with attributes which were used for multiple different objectives.

4.2.4. *What indicators are used for measurement and verification?*

For this work, indicators are considered to be quantifiable parameters used to evaluate the outcomes of actions of the EP activity in relation to the achievement of the objectives set. Indicators provide a description of the energy system, and changes in their values over time provide information as to the progress, or opposite, in relation to the planning activities and the decisions made [36].

None of the plans reviewed included any indicators with the specific purpose of monitoring or evaluation after plan implementation. Targets, however, 26 in total, were cited in the documents and used to state desired outcomes.

The targets could provide a starting point for the development of quantifiable indicators for the EP activities. Commonly the targets included a desired outcome, often cited in the form of a

Table 4
Attributes and objectives.

Themes ↓	Attribute	Objectives								
		S1	S3	S4	Ec1	Ec2	En1	En2	En3	No Obj.
Social	Share of households with energy access by carrier	D2								
	Share of households with energy access by carrier from renewable sources	D2								
	National capacity for implementing the option								D6	
	Capacity for target groups to operate, maintain and eventually improve the new technologies								D6	
	Adequacy of the options to meet national development objectives								D6	
	Electricity consumption per capita					D15				
	Number of electricity customers					D15				
	Share of population in location with electricity					D15				
	Annual trend of primary energy supply per capita				D11					
	Annual trend of electricity supply per capita				D11					
	Share of public kitchens with improved cookstoves				D2					
	Share of public kitchens with solar hot water heaters (hotels, restaurants, institutions)				D2					
Economic	Cost for avoided CO_2 emissions								D6	
	Investment Cost (includes levelized and per unit of energy)			D4	D11, D14	D12			D6	D3, D9, D15
	Cost of electrical energy generation (includes over project lifetime accounting for fuel cost fluctuations)			D4	D14					
	Economic internal rate of return			D4						
	Cost Benefit ratio			D4						
	Economic net present value			D4						
	Annual savings of conventional energy sources			D4						
	Impacts on other economic sectors								D6	
	Annual trend in marginal cost of electricity				D11					
	Average annual marginal electricity cost by area inside of each ECOWAS member state		D12							
	Fuel cost					D12				
	Number of direct jobs created for construction, operation, and maintenance				D14					
	Overall impact of mitigation options at macroeconomic level								D6	
	Additional environmental benefits at local or regional level								D6	
	Employment generation								D6	
	Net benefit (monetary)								D6	
	Average cost of sequestered carbon								D6	
	Total Operation, maintenance, and fuel costs				D11					
	Average annual electricity generation cost				D11					
	Change in annual cost of imported fuels				D14					
	Cost of land preparation for carbon sequestration								D6	
	Total benefit of land exploitation for carbon sequestration								D6	
Environmental	CO_2 emissions				D11		D1, D9, D14		D6	
	Use of manganese instead of ethanol as additive to gasoline						D2			
	Sulfur content in gas oil (automobile diesel)						D2			
	Total sequestered carbon								D6	
Energy system specific	Ratio of import to domestic petroleum products				D2					
	Raito of import to export of petroleum products				D2					
	Ratio of stock of refined oil products to national demand	D2				D2				
	Ratio of stock of crude oil to national demand	D2				D2				
	Change in annual imported fuels				D14					
	Fuel shares in energy and electricity				D11		D2		D6	D1
	Annual and total fuel savings by fuel type								D6	
	Annual final energy demand by carrier, and by sector	D9			D11, D14	D8, D15		D9	D6	D1, D4
	Annual final energy consumption by carrier, and by sector					D12			D6	
	Energy intensity by sector and carrier	D2			D2					
	Annual diesel fuel demand									D4
	Fuel consumption per GDP in transports						D2			
	Annual power factor for the industry sector				D2					
	Share of national energy mix from renewable energy sources				D2					
	Share of electricity generation by energy conversion type (generation capacity or energy generated)				D2, D11, D14	D12, D14				D4
	Annual installed peak electricity generation capacity					D8, D10, D15				
	Annual peak electrical energy demand					D8, D10, D12, D15				D13
	Surplus and/or deficit electrical energy generation capacity (MW)				D11	D8				
	Annual electrical energy generation					D8, D12				
	Surplus and/or deficit electrical energy generation (MWh)					D8				
	Electrical energy imports and exports (includes total and ratio to domestic)				D9	D12				D15
	Reliability of electricity supply system	D2				D2				
	Transmission lines installed					D15				
	Distribution lines installed medium and low voltage					D15				
	Availability of Local and Imported Components									D4

Table 5
Document Demand Considerations and Scope.

Document	Energy Demand Forecast Method	Urban and Rural Modeling Separation	Document Planning Horizon (years)	Number of Scenarios Presented	Number of planning alternatives considered	Modeling tools cited	GHG consequences quantified in forecast	Additional pollutant emissions consequences quantified in forecast
D1	Hybrid	Yes	9	2	1	–[a]	CO_2	–[b]
D2	Bottom-Up	Y	14	3	4	MESSAGE, LEAP, Integrated Resource Planning, RETScreen	CO_2, CH_4, N_2O	NO_x, So_x, Non CH_4 VOCs, Particulate Matter
D3	Statistical	Y	9	1	0	MAED, WASP	–[b]	–
D4	Hybrid	Y	20	1	1	–	–	–
D5	Hybrid	No	30	4	0	LEAP, COMAP	–	–
D6	Bottom-Up	N	15	1	0	MAED	CO_2	–
D7	Statistical	N	15	1	0	Multiple Regression Time Series	–	–
D8	Top-Down	Y	11	2	0	–	–	–
D9	Statistical	Y	21	1	0	–	–	–
D10	Statistical	Y	5	1	0	–	–	–
D11	Bottom-Up	Y	25	1	3	MAED, WASP	–	–
D12	Top-Down	N	14	2	0	–	–	–
D13	Unclear	N	25	3	0	–	–	–
D14	Top-Down	N	11	3	3	SIMRES, PVSist,Wind Atlas Analysis and Application Program(WAsP), KAMM	CO_2	–
D15	Statistical	N	19	1	0	–	–	–

[a] "–" not cited
[b] "–" none

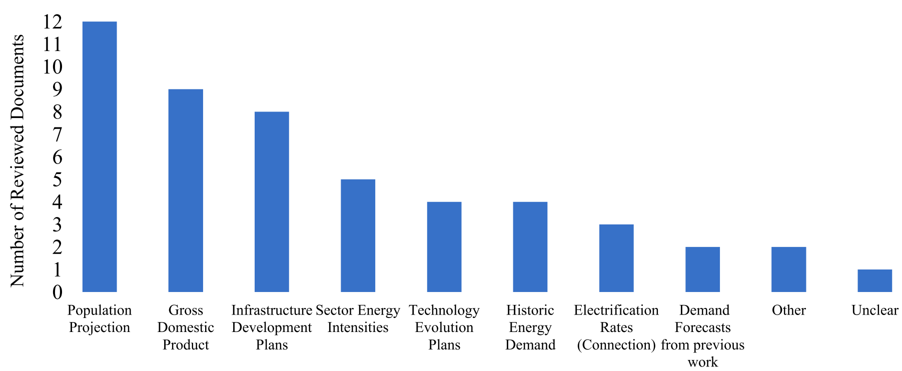


Fig. 8. Factors considered for energy demand forecast.

percentage of a total in a specified amount of time, or most often in a future year. Examples are "share of the population with access to energy [%]" (100% in D1), "share of population with coverage of electricity grid and/or natural gas cylinder sales network" (90% in D1), or "modern fuel adoption by households currently reliant on biomass for cooking" (50% in D3) or "renewable electricity generating capacity [MW]" (10.5% in D13).

Yet these were not considered indicators as they were not presented with clear methods of quantification nor a plan for measurement and verification, but as an idealized target.

4.3. *How is energy demand considered?*

4.3.1. *How is energy demand forecasted?*

The energy demand forecast methods employed in the EP activities are presented in Table 5.[2] While 5 of the documents followed a statistical method (Past-future use projection), D3, D7, D9, D10 and D15, the most common method employed was a bottom-up approach (End-use Approach), used either exclusively as in D2, D6 and D11, from Ghana, Senegal, and Ghana respectively, or within a hybrid method (Bottom-up and Top-Down) as was the case in D1, D4 and D5, from Cape Verde, The Gambia, and Nigeria respectively. A Top-Down approach (Economic approach) was used in 3 documents from D8, D12 and D14. The method used was unclear in D13, from Nigeria.

4.3.2. *What factors are considered in the demand forecast?*

The factors used within considerations in the energy demand forecasts are presented in Fig. 8. The most common criterion was *population projection,* which was employed in 12 of the EP documents. Following this criterion, *gross domestic product* projections as well as considerations of *infrastructure development plans* were the most common in the documents and were considered in 9 and 8 of the documents considered. The criterion *demand*

[2] Modeling tool abbreviations: MAED—Model for Analysis of Energy Demand—from the International Atomic Energy Agency(IAEA), LEAP—Long-range Energy Alternative Planning—from the Stockholm Environment Institute, WASP—Wien Automatic System Planning Package for electricity generation expansion planning—from the IAEA, MESSAGE—Model of Energy Supply Systems and their General Environmental Impacts—from the IAEA, SIMPACTS—Simplified Approach for Estimating Impacts of Electricity Generation—from the IAEA, SIMRES—Generational unit commitment scheduling model—Source UNKNOWN, PVSyst—Photovoltaic System

(*footnote continued*)
Studies, Sizing and Simulation Software, RETSCREEN—Renewable-energy and Energy-efficient Technologies Clean Energy Project Analysis Software—from Natural Resources Canada, COMAP—Comprehensive Mitigation Analysis Process for forestry, IRP—Integrated Resource Planning, WAsP—the Wind Atlas Analysis and Application Program, KAMM—Karlsruhe Atmospheric Mesoscale Model

forecasts from previous work refers to forecasts previously presented in separate documents. The *other* criterion here includes consideration of tourism, with a count of beds, used in D1 for Cape Verde as well as survey results for biomass consumption in Benin, D3. The criteria considered for one document, D13 for Nigeria, was *unclear*.

The informal sectors make up a large part of the economic activities in developing countries, and in Sub-Saharan Africa the size of the informal sector was estimated to be more than 40% of the gross national product in 2003 [37,38]. Here the informal sector is considered unregistered companies, often run from homes [39]. [3] The informal sector was not explicitly considered in any of the documents reviewed.

Suppressed demand (i.e. needed energy services currently not supplied) is common due to budget constraints, resulting in less energy services demands in poorer areas. A lack of infrastructure also prevents demands from being met [41]. Suppressed demand is important to consider, as looking solely at historic consumption overlooks these demands which may be manifested in the future if economic conditions improve. Suppressed demand for energy by populations was considered in the modeling of demands in 3 of the documents (D4, D8 and D12).

4.3.3. Are distinctions made between urban and rural energy demands?

Substantial differences exist between urban, rural, and peri-urban areas in developing countries. Populations in urban areas often have starkly different rates of access to modern energy services as opposed to rural and peri-urban areas. EP activities in developing countries should account for differences in these populations and areas.

It was found that the demand modeling for urban and rural populations was done separately in eight of the 15 documents reviewed (Table 5).

4.3.4. How long are the planning horizons considered?

The planning horizons considered in the documents are presented in Table 5. Here the planning horizons are categorized within five year periods. Only D10, from Sierra Leone had a short term planning horizon, 0–5 years. A medium term planning horizon was most common and 11 of the documents had horizons between 9 and 21 years. Longer planning horizons of 25 years or more were found in three documents.

4.3.5. How many scenarios are considered?

It is important to clearly delineate the terms used here to describe energy demand forecasting in the EP documents. *Forecasts* provide information about probable future situations often relying on past trends to provide a basis for extrapolation into the future. Scenarios then are those which are built upon factors which are not within the control of the modeler, but are quite relevant to future situations [42].

The economic development path of many developing areas is uncertain, requiring that EP activities take considerations for potential discontinuities in this development. The inclusion of multiple economic scenario forecasts allows for an understanding of energy demands within different development paths which may arise. Considering multiple scenarios is a way to deal with this uncertainty in future development paths, making for more robust EP [43].

[3] Additional discussions of informal activities and definitions can be found in Garcia-Verdu [40].

The number of scenarios considered by the EP documents is presented in Table 5. Only one scenario is presented in 8 of the 15 documents.

Where multiple scenarios are considered, they were constructed from variations of the economic development scenarios. As is the case in D1, for Cape Verde with two scenarios in which both moderate and accelerated growth scenarios are used, as well as D5, for Nigeria, with four scenarios, a reference, a high and two optimistic economic growth scenarios are considered. Documents with two scenarios included D1, D8, and D12, and with three scenarios D2 and D13. As mentioned above, D5 was the only document with more than three scenarios.

All of the documents reviewed constructed scenarios for the purpose of forecasting energy demands, and so presented energy demand forecasts with the scenarios. It was, however, difficult to separate the two within the documents reviewed. In documents with only one scenario, there was not a discussion of the scenario followed by a description of the planning alternative considerations but actually a forecast of energy demands together with assumptions encapsulating both the scenario and the planning alternative. This means essentially that the scenario and the planning alternative were considered one and the same (while there could have been several alternatives within the same scenario—see next section).

4.3.6. How many planning alternatives are presented?

An *alternative* here is considered to be a hypothetical set of measures, which results in a future which reflects different outcomes as compared to the base-case. It is constructed over *scenarios,* which are not within the control of the user.

The number of documents which included planning alternatives is presented in Table 5.

Of the documents reviewed ten did not present any planning alternatives. Two documents, D1, for Cape Verde, and D4, for Gambia, presented one alternative based on implementation of Demand Side Management (DSM) measures and renewable energy considerations respectively. D11, for Ghana, presented three alternatives, constructed from different policy options, for increasing the share of renewable energy options. D2, for Ghana, presented one alternative considering implementation of a Demand Side Management (DSM) program, and three separate supply side alternatives considering different combinations of electricity generation technology options.

4.3.7. Are considerations of energy demand side management measures made?

One alternative to consider in the evolution of energy demands is the inclusion of DSM program measures. The scope of DSM activities has undergone a number of changes in recent years as a result of new communication technologies, technological advancements, and an understanding that DSM activities are not limited in scope to electrical utility planning but can include other energy considerations and planning activities, e.g. transportation fuels, other energy carriers, and urban planning. Suganthi and Samuel [44] point out that energy demand management activities aid in future planning activities identification of opportunities for energy conservation, identification and prioritization of energy resources, framing policy decisions, and strategies for reduced environmental impacts.

DSM measures were considered and modeled in only two of the documents reviewed. D1 from Cape Verde presented an alternative considering DSM, referred to as rational energy use. D2, from Ghana, included a modeled alternative based on the application of a DSM program.

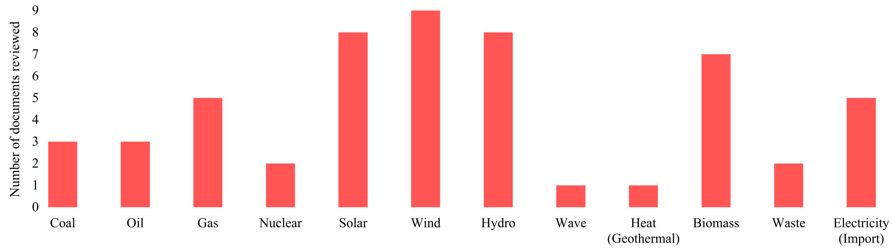


Fig. 9. Primary Energy Sources Considered.

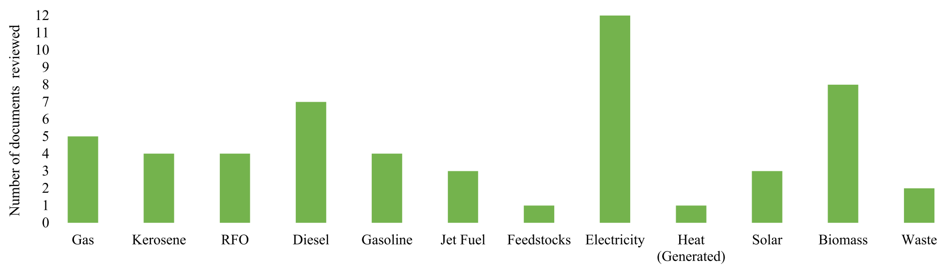


Fig. 10. Secondary/Final Energy Carriers Considered.

4.4. What is the scope of the EP activity?

4.4.1. What modeling tools are used?

The modeling tools used in the documents reviewed are presented in Table 5. The modeling tools considered here are those which are cited as being used in the formulation of the current document, and do not include tools used in works cited.

Of the documents reviewed two, D5 and D11, cited MAED (abbreviations are included with Table 5) from the International Atomic Energy Agency (IAEA). The LEAP model software from the Stockholm Environment Institute was employed in two of the documents, D2 and D6.

On the supply side, two documents, D5 and D11, cited the WASP from the IAEA, and one of the documents, D2, cited the MESSAGE from the IAEA. The package SIMRES a generation unit commitment scheduling model was cited in one documents D14.

Tools used for renewable energy project analysis included RETSCREEN, as well as PVSyst. RETSCREEN was cited in one document from Ghana, D2, and PVSyst was cited in D14 from Cape Verde.

The COMAP was cited for use in modeling forestry concerns in one document, D6.

Two tools, considered methodologies but not software packages, are also presented. They included IRP, D2, applied in Ghana, and a multiple regression time series analysis, D7, used in Nigeria.

The wind resource modeling tools of WAsP, from the Risø National Laboratory in Denmark and KAMM were used in combination in D14 for local predictions of wind resources for power production from wind turbines and wind farms.

4.4.2. Which primary energy sources and energy carriers are considered?

Primary energy sources are those which are extracted or taken straight from natural resources. Energy carriers, often referred to as final or secondary energy, are produced from primary energy sources or other energy carriers and are those which enter into the actual place of use, i.e. the household [45].

The primary energy sources, shown in Fig. 9, most commonly considered in the documents were from renewable sources.[4] Wind was considered in nine documents, both Solar and Hydro in eight documents, and Biomass in seven documents. Gas was the most commonly considered fossil fuel energy source, stated in five documents. Imported electricity was cited in five documents, from countries located on the continent.

The secondary/final energy carriers cited are shown in Fig. 10.[5] Electricity was considered in 12 of the documents. Biomass was the second most commonly considered of the carriers and was included in eight of the documents. Diesel fuel was considered in seven of the documents, and gas was cited in five of the documents. Kerosene, RFO, and gasoline were all cited in four of the documents.

Demand for traditional energy carriers remains the largest final energy demand in the ECOWAS region, representing 80% of final energy demand [3]. Biomass was considered in eight of the 15 documents as part of considerations for energy carriers.

4.4.3. Are environmental consequences of energy use quantified?

Quantification of CO_2 emissions according to each future alternative, was found in four of the documents, D1 from Cape

[4] Gas refers to LPG, butane, propane and other gas mixtures. Solar refers to solar energy used in both PV and thermal technologies for electricity and heat production respectively. Hydro includes large scale as well as small or micro hydro for electricity generation. Wave refers to ocean wave energy technologies, but not tidal technologies. Heat refers to geothermal heat. Biomass includes both woodfuel collected and charcoal. Waste includes agricultural and municipal waste (trash) destined for combustion, it does not include waste destined for gas extraction.

[5] Gas refers to LPG, butane, propane and other gas mixtures. Residual fuel oil (RFO) is used synonymously with Heavy Fuel oil (HFO). Diesel includes derivatives such as marine diesel, a mixture of diesel with fuel oil. Gasoline includes premix gasoline fuels. Jet Fuel includes Jet A and Jet A-1 also misnamed “petroleum” and used for indoor lighting in Cape Verde see D1. Feedstocks are petroleum based chemicals for manufacturing processes. Heat is generated in combined heat and power systems. Solar refers solar energy which is used in both PV and thermal purposes for electricity, heat production, and drying. Biomass includes both woodfuel collected and charcoal. Waste includes agricultural and municipal waste (trash) destined for combustion, it does not include waste destined for gas extraction.

Verde, D2 from Ghana, D6 from Senegal, and D14 also from Cape Verde. Only one document, D2 from Ghana, included the quantification of specific additional greenhouse gases, namely CH_4 and N_2O as well as four other polluntant emissions. Table 5 presents the number of documents which included the quantification of environmental ramifications due to energy demands.

5. Specificity of the indicators

As part of this review of EP activities, a review of indicators used was conducted to establish an understanding of the level of specificity of EP indicators for the region and possibly developing countries in other regions.

The Environmental policy from the ECOWAS Commission [46] requires states to carry out environmental studies or impact assessments on investments and actions with potential environmental impacts. Assessment activities which should run in conjunction to EP activities require quantifiable indicators which allow for measurement and verification activities. International aid organizations have included Environmental Impact Assessment (EIA) or SEA type requirements for lending and development programs [47].While a number of sets of energy based indicators have been presented, there is not a consensus as to the level of specificity needed in indicators for different contexts of application, and especially in developing countries [13,19,36,48–54]. There have been no studies of indicators for specific application in the framework of EP activities of Sub-Saharan Africa or specifically ECOWAS members.

A number of energy based indicator sets have been presented recently. These include general sets of sustainable energy indicators from Vera and Langlois [36], International Atomic Energy Agency (IAEA) [50], and Patlitzianas, Doukas [55]. The European Environment Agency (EEA) [52] also presented indicators for use in more developed countries, within the context of the European Union. A set of energy based indicators, for local EP in more developed countries, was presented by Neves and Leal [19]. Kemmler and Spreng [49] and Neves and Leal both presented sets of core or lead indicators as subsets of indicators meant to provide a *dashboard* analysis of important measures of the system in question for policy considerations. While these provide examples of indicators they may not always be complete sets which are expressly applicable to the context of developing countries.

Indicators describing a country's transition to modern energy, measuring energy poverty indicators were explored by Kemmler and Spreng [49]. The sets for measuring the impacts of energy reforms for the specific countries of Mexico and of Guatamala, developing nations of Central America, have been established by Sheinbaum-Pardo, Ruiz-Mendoza [48] and Foster and Tre [51] respectively. The World Bank presents an annual review of African Development through a large set of African Development Indicators which detail some parts of the energy sector [13]. The United Nations presented a preliminary set of general sustainable development indicators for African countries [53]. The Poor People's Energy Outlook presented indicators more specific to the energy sector in developing countries and made considerations for energy's importance for earning a living and the importance of energy at the household level [54].

Two sets of energy sustainability indicators for local EP for use in developed countries, presented by Neves and Leal [19] were used as part of this work for juxtaposition with indicators used within the ECOWAS region. The first set consisted of 59 energy based indicators, resulting from a literature review of sustainability indicators. The second set resulted from a methodology of refinement of the first set to a revised set of 18 state and policy energy based indicators for local EP.

Monitoring and evaluation intentions were absent at the EP stage of the documents reviewed. In the EP documents recovered for this work, as discussed previously, no indicators for monitoring plans were found and so as a proxy the attributes stated in the documents were used for comparison. With the EP documents reviewed for this work, any measure of impact of the plan against a "no plan" future would not be possible without indicators and monitoring plans. It must be noted that one document, D2 from Ghana, stated that SEA activities would be completed with the plan, however no SEA or monitoring plan was provided together with the plan. The Ghanaian Environmental Protection Agency requires SEA activities to be completed with energy sector projects of this scale [56].

Less than 50% of the indicators presented by Neves and Leal [19] as energy based sustainability indicators were employed in the ECOWAS member states documents, and only three of these indicators were commonly cited in the documents (Table 6). These included indicators pertaining to renewable energy shares, annual energy consumptions, and Greenhouse Gas emissions. Within the 2nd more refined list of local energy based sustainability indicators proposed by Neves and Leal, only indicators for renewable energy shares, and greenhouse gas emissions were widely employed in the documents reviewed. This comparison is not presented in table form here, as the indicators are also present in the first list, however the results are discussed.

Few similarities were found between the attributes in the documents reviewed and the indicators employed or recommended for use in planning activities of developed countries. This may represent a specificity of these indicators to developed countries, but it also may represent a gap in the planning activities of the ECOWAS region. As the plans reviewed lacked indicators for monitoring and evaluation, there is still some development needed in the planning activities in order to ensure that they employ metrics and procedures which link objectives from the plan formulation through to assessment activities.

The specificity of the indicators should also be assessed, from the other side, to evaluate those used in the ECOWAS member states but not in the list presented from Neves and Leal [19], and attributes such as *new connections to the grid*, *trend in marginal costs of electricity*, *capacity to maintain and operate new technologies* attest to the specificity of attributes to regional objectives.

Documents 1 and 2, from Cape Verde and Ghana respectively, both employed the largest number of indicators on the list. They are also the 2 ECOWAS member states classified as Medium Human Development by the UNDP.

Future work may include a further assessment of energy based indicators and the proposal of a set of indicators which would aid actors involved in EP activities in the region and a method to include these in EP activities

6. Conclusions

The application of a matrix of evaluation to a comprehensive set of energy plans provided a characterization of the EP activities within the ECOWAS region, with the aim of establishing an understanding of current EP practices in the region and presenting a set of recommendations which may aid in future effective EP activities. The conclusions are presented in a question-driven format including recommendations for each topic analyzed.

6.1. Who is active in EP activities?

EP documents conforming to the requirements of this review (i.e. having a quantified demand forecast) were discovered for 10 of the 15 ECOWAS members and the WAPP.

Table 6
First set of 59 energy based indicators from Neves and Leal (2010) versus those found in ECOWAS plans.

Energy Based Sustainability Indicators (Neves and Leal 2010)	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	Count
Share of households (or population) without electricity or commercial energy	✓	✓	✓												✓	4
Share of household income spent on fuel and electricity																0
Household energy use for each income group and corresponding fuel mix																0
Accident fatalities per energy produced by fuel chain																0
Energy use per capita														√(14)	✓	2
Energy use per unit of GDP																0
Efficiency of energy conversion and distribution																0
Reserves-to-production ratio																0
Resources-to-production ratio																0
Industrial energy intensities																0
Agricultural energy intensities																0
Service/commercial energy intensities		✓														1
Household energy intensities		✓														1
Transport energy intensities		✓														1
Fuel shares in energy and electricity	✓	✓				✓			✓							4
Non-carbon energy share in energy and electricity		✓									√(9)	√(11)				3
Renewable energy share in energy and electricity	✓	✓		✓							✓	√(11)	✓	✓		7
End-use energy prices by fuel and by sector		✓									√ (10)					2
Net energy import dependency		✓							√(8)		✓			✓		4
Stocks of critical fuels per corresponding fuel consumption		✓														1
GHG emissions from energy production and use, per capita and per unit of GDP	√(1)	√(1)							√(1)		√(1)			√(1)		5
Ambient concentrations of air pollutants in urban areas																0
Air pollutant emissions from energy systems	✓	✓				✓										3
Contaminant discharges in liquid effluents from energy systems																0
Oil discharges into coastal waters																0
Soil area where acidification exceeds critical load																0
Rate of deforestation attributed to energy use																0
Ratio of solid waste generation to units of energy produced																0
Ratio of solid waste properly disposed of to total generated solid waste																0
Ratio of solid radioactive waste to units of energy produced																0
Ratio of solid radioactive waste awaiting disposal to total generated solid radioactive waste																0
Average satisfaction with the local community																0
Business demography																0
Attendance at community group meetings																0
GHG emissions by sector						✓			✓							2
Combined heat and power generation																0
Energy consumption by transport mode	✓															1
Access to public transport																0
External costs of transport activities																0
Emissions of air pollutants from transport activities	✓															1
Share of major proposals with an impact assessment																0
Responses to EC internet public consultations																0
E-government on-line availability																0
E-government usage by individuals: total																0
CO_2 removed by sinks						✓										1
External costs of energy use																0
Energy tax revenue																0
Road share of inland freight transport																0
Modal split of freight transport	√(2)															1
Freight transport prices by mode																0
Investment in transport infrastructure by mode																0
Annual energy consumption, total and by main user category	✓	√(4)		√(4)		✓		√(7)				√(12)		√(13)	✓	8
Modal split of passenger transport	√(2)															1
Percentage of population using solid fuels for cooking		√(5)														1
Eco-efficiency of economic activities																0
Use of cleaner and alternative fuels		√(6)														1
Projections of GHG emissions and removals and policies and measures	✓					✓					✓			✓		4
Global and European temperature																0
Atmospheric GHG concentrations																0
Count	11	15	1	2	0	6	0	1	4	0	6	3	1	6	3	

(1) Greenhouse gas emissions from energy production and use. Does not include by sector or per capita.
(2) A projection of vehicle type and vehicle consumption is made by road, maritime and air, but not a modal split by freight and passenger.
(3) Included in discussion but no attribute or target specified.
(4) Does not include main user category, is divided by fuel type.
(5) Woodfuel energy intensity per urban and rural household [*assumed* tons/household].
(6) Use of manganese instead of ethanol as additive to gasoline, Sulfur content of diesel [ppm],
(7) Annual electrical energy, fuelwood demand [MWh, ton].
(8) Ratio of electrical energy imported to domestic [%].
(9) Annual primary energy supply by energy source [%], Annual electrical energy generation by primary energy source [TWh].
(10) Annual trend in marginal cost of electricity [indexed to 2005 cost].
(11) Annual share of electrical energy generated by primary energy source [%].
(12) Annual electrical energy consumption [MWh].
(13) Annual electrical energy demand by sector [MWh].
(14) Electrical Energy Use per capita.

Both local and foreign contributions were found in the EP activities, with common collaboration between local and foreign actors. Initiative for the planning activity and management was predominantly provided by local government ministries and agencies. Local technical effort was also seen from government ministries and agencies as well. Foreign technical effort from international organizations and consultants was common throughout the documents.

Recommendations:

- Ensure that the EP activity is not be overlooked, on any scale national to local, as it can greatly aid the development of energy policies and provide "roadmaps" of how achieve energy visions.
- Establish dedicated government resources or agencies, covering all levels of EP, to ensure that the EP activity is carried out and that this EP activity produces EP documents which are accessible to policy makers and possibly to the public.

6.2. What is the purpose of the EP activities?

All of the EP documents recovered were for national EP purposes. EP documents with quantified demand forecasts on the local scale as well as for rural areas were not found either through the internet search or through the inquiry of ECREEE NFI contacts, most probably implying that they do not exist. The perceived absence of EP activities at these scales, below the national level, is of importance as, for example, populations in rural areas commonly have less access to modern energy services than urban populations.

Electrical system planning documents were the most common type, representing 9 of the 15 documents recovered. Energy master planning documents considering a wider range of energy carriers were less common representing 3 of the 15 documents recovered. EP master planning efforts allow for the consideration of multiple energy carriers in addition to electricity and allow for the matching of energy demands with different carriers permitting actors to evaluate the carrier most suited for particular demands given specific circumstances. Considering multiple energy carriers may also allow actors to consider alternatives where primary and final energy supplies are more diversified.

Cited objectives were predominantly economically themed. The most commonly cited objectives within the social, economic and environmental themes were to increase access to modern energy, to increase security of energy supply, increase system reliability, and to minimize environmental impacts attributed to the energy sector.

The fundamental objectives for the EP activity were not explicitly stated in all of the EP documents reviewed, but implied through means objectives. Also disconnections were found between the objectives set for the EP activity and attributes employed to pre-assess the achievement of these objectives. There were a number of objectives set in the EP process which could not be clearly linked to attributes in the planning process. The reverse was also found: a number of attributes were employed but could not be specifically linked to an objective. Also, EP objectives could be linked to a wide array of different attributes as well as attributes being linked to multiple different objectives. Attributes were also found to be most often used in a diagnosis capacity rather than used in the decision making processes of analyzing alternatives.

No indicators for future monitoring and evaluation activities explicitly referred to as such, were found in the EP documents. However, there were EP documents which cited loosely defined targets as desired outcomes. Without monitoring and evaluation, the outcomes and effectiveness of these EP activities cannot be assessed, and no corrective measures can be adopted in due time. There may also be a financial side here, which means that governments or agencies involved will not know how effectively funds and budgets for EP will actually be applied.

There are currently available in the literature, examples of both attributes and indicators for most of the objectives found in the EP documents reviewed [50]. For example the objective "To improve ability to provide affordable energy" Sc3 could probably be appropriately translated through the indicator "share of household income spent on fuel and electricity and household energy use for each income group and corresponding fuel mix" [50,51].

Recommendations:

- Establish EP activities at the local and rural level which assist in the development of energy policies for municipalities and cities and address EP issues associated with urban, peri-urban and rural populations. These also support national policy development.
- Shift EP activities to also include energy master planning activities as these planning efforts allow for the inclusion of additional energy carriers, e.g. natural gas, generated heat, biomass, solar (for photovoltaic and water heating) etc., which may lead to systemic gains.

Globally, from the evaluation of objectives, attributes and indicators of EP processes in the ECOWAS region, there seems to be a need for more structured planning practices, which enable initiative and process management actors to better design the plans.

Recommendations:

- Identify *fundamental* objectives as these provide the foundation for decision processes, explain the overarching reasons for which the EP activity is undertaken, and establish structure in the EP activity [57]
- Translate objectives into attributes as part of a structured decision-making process, ensuring that decision alternatives are created and that the choice among them considers their potential to fulfill the stated EP objectives.
- Include indicators for considerations of measurement and verification in order to evaluate the outcomes and effectiveness of EP activities.

6.3. How is energy demand considered?

The energy demand forecasting methods described, in the documents where it was addressed, consisted most commonly of statistical (past to future) projections. However bottom-up methodologies, either solely bottom-up or within hybrid methods, were also common.

An interesting observation was that energy demand which is currently considered suppressed/unmet was included in the modeling of demands in three of the 15 documents. As many areas have not had the physical access or financial ability to access modern energy services, a simple projection of historic growth of consumption data may leave out the demands which these populations represent. Also documents did not specify if the informal sector was considered in energy demand forecasts. This may be problematic given the energy demands which informal activities are undoubtedly responsible for as they constitute a large percentage of the economic activity within these countries.

Bottom-up or hybrid methodologies allow for planners to start from the energy services which end-users actually demand and to include demands which may be overlooked in statistical

projections. Also with a bottom-up method starting from the end-user energy services energy demands allows for considerations of multiple energy carriers in meeting different demands and is conducive to master planning activities.

The EP horizons are predominantly medium term, and 11 of the documents had horizons between 9 and 21 years.

The criteria used in the forecasting methods were primarily considerations of population projections, GDP projections, and infrastructure development plans. Criteria such as historic trends of energy demands were also employed.

Distinctions were made for urban and rural populations in eight of the documents reviewed; peri-urban populations were not discussed in the documents.

The majority of the documents, eight of 15, consider only a single scenario. When multiple future scenarios are presented, these are based on different economic growth scenarios.

The line between the scenario, planning alternatives, and demand and primary energy supply forecasts was not clear in the majority of the documents reviewed. The scenario and energy demand forecasts were presented as one and the same. Also, planning alternatives representing different policy initiatives, for example, were absent in ten of the documents reviewed. The absence of alternative future scenarios and the consideration of planning alternatives affect the robustness of the planning process.

Recommendations:

- Ensure that the EP methodology employed is best suited to the context of the application. As suppressed/unmet demands as well as informal sector demands are mostly absent from historical data, a statistical (past to future) projection may be inadequate in forecasting energy demands.
- Include considerations of rural, urban and peri-urban populations in national level planning or local city or municipal planning efforts as urban populations in the region are projected to grow in the near future and these represent distinct population types [58].
- Ensure robust EP activities by considering multiple possible scenarios as the future is uncertain and a single future scenario provides little information for other possible futures. These can include economic growth scenarios as well as others.
- Develop multiple constructed alternatives in EP activities of the region to allow for the evaluation and comparison of different policy measures to be considered in their achievement of stated objectives. The assumptions for these alternatives and their evaluation, with attributes, should be clearly presented and compared in the EP document. This allows for transparency in the methodology but also presents the policy makers and public with information which allows for construction of appropriate energy policies to achieve objectives.

6.4. What are the scope and tools being adopted?

The tools used within the EP activity were diverse, from international sources and common to those used within developed countries. These tools include energy demand and supply side models such as LEAP, renewable energy project analysis including RETScreen, and biomass supply models. Not all of the EP documents reviewed cited the modeling tool employed.

Renewable energy supplies were the most common primary energy sources considered, including solar, wind, hydro and biomass sources. The next most commonly considered was natural gas. This may reflect the development of the West African Gas Pipeline (WAGP) which would increase the availability of gas in ECOWAS members with connections. Electricity imports were also considered in numerous documents reflecting the development of the West African Power Pool (WAPP) and the interconnections that this allows and will allow. As concerns of increased energy security and decreased environmental impacts were expressed in the EP objectives cited in the documents it is important for countries in the region to not only consider a shift to renewable energy supplies, but also options such as diversification of resources.

As renewable energy supplies often require technologies which cost a premium over fossil fuel technologies, which are less proven in the ECOWAS region, and which rely on intermittent resources, these may not always be the optimal solution based on the EP objectives set.

EP activities within ECOWAS will have to consider recent regional energy market developments. The WAPP will allow for the import and export of electrical energy between the member states. Also the construction of the WAGP will permit natural gas exchanges between member states. These efforts will aid in establishing energy markets for the community composed of states with diverse primary energy resources [59].

Electricity was the most commonly cited energy carrier. Other carriers, e.g. diesel and natural gas, are also considered, but as electricity systems plans were the most common, electricity was also the most common carrier considered. This also reflects objectives set in the region, not only for access to modern energy, but specifically for increased access to electricity [3]. Consideration of traditional energy, e.g. biomass or woodfuel, was found in eight of the documents.

The environmental ramifications of the alternatives presented in the EP activity were not considered in the majority of the documents. However four documents included forecasts of CO_2 emissions and of these, one, D2 from Ghana considered other GHG and additional pollutant emissions.

Recommendations:

- Include considerations of primary energy supplies and their sources, including fossil fuels (e.g. oil and natural gas) and not solely a shift towards renewables as part of energy security considerations.
- Include considerations of multiple final energy carriers in master planning efforts, and allow for the consideration of multiple carriers in meeting the demands of end-users for energy services. Energy demands for cooking, an energy service, could be met by electricity (grid or solar photovoltaic), natural gas (grid or bottle), or direct solar for example.
- Include the quantification of the environmental implications when modeling and forecasting alternatives. As this allows for the evaluation of these alternatives in their fulfillment of objectives to minimize the environmental impact of energy systems.

6.5. Specificities of EP activities

While improving access to modern energy services may represent a specific objective to the realities of ECOWAS countries, it may be considered that most of the EP objectives identified here are similar to those of developed countries. The objectives “improve security of energy supply” (Ec1), “improve system reliability” (Ec2), “increase economic development” (Ec3), “minimize environmental impacts and climate change impacts” (En1 and En2) are examples of objectives which are also common to EP activities in developed countries which fall into “three E” themes of energy security, economic revitalization, and environmental protection [60].

It is unclear whether the apparent convergence of objectives with the pattern of those from developed countries represents a fundamental nature or whether it represents mostly borrowing

Table A1
Original EP Fundamental and Means objectives.

Document	**Fundamental objectives [*Authors' addition, in absence of fundamental objective*]**	**Means objectives**	**Comments**
D1	Improvement of the comfort and the quality of life of inhabitants		
	[Increase economic development]	Growth of national economic competitiveness	
	Security of supply (of energy)		
	Environmental preservation		
D2	*[Increase economic development]*	Stimulate economic development by ensuring that energy plays a catalytic role in Ghana's economic development	“Catalytic role” is not defined and difficult to quantify and control
	[Increase system reliability] [Increase access to modern energy]	Consolidate, improve and expand existing energy infrastructure	
	[Increase access to modern energy]	Increase access to modern energy services for poverty reduction in off-grid areas	
	[Increase security of energy supply]	Secure and increase future energy security by diversifying source of energy supply	
	[Increase security of energy supply]	Accelerate the development and utilization of renewable energy and energy efficiency technologies so as to achieve 10% penetration of national electricity and petroleum demand mix respectively by 2020	
	[Increase economic development]	Enhance private sector participation in energy infrastructure development and service delivery	
	[Minimize environmental impacts attributed to the energy sector]	Minimize environmental impacts of energy production, supply and utilization	Three means objectives can be identified here
	[Improve governance of the energy sector]	Strengthen institutional and human resource capacity and R&D in energy development	
	Improve governance of the energy sector		
	[Increase economic integration of West African States]	Sustain and promote commitment to energy integration as part of economic integration of West African States	
D3	*[Increase access to modern energy]*	Increase access to modern cooking services	
	[Increase access to modern energy]	Increase access to modern mechanical and electrical services to rural populations	
	[Increase reliability of energy]	Ensure reliable electrical supply to urban and peri-urban households	
D4	*[Minimize environmental impacts attributed to the energy sector]*	Provision of efficient energy	
	Provision of reliable energy		
	Provision of affordable energy		
	[Minimize environmental impacts attributed to the energy sector]	Ensure that exploitation of energy is sustainable and environmentally sound	
D5	*Unclear Objectives*	–	
D6	*[Minimize climate change impacts attributed to the energy sector]*	Greenhouse Gas Emissions Mitigation	
D7	*[Increase system reliability]*	Forecast Electricity Consumption	
D8	*[Increase system reliability]*	Identify electricity generation options required to meet immediate demand, consistent with future development scenarios	
D9	*[Minimize environmental impacts attributed to the energy sector]*	Curb deforestation through promotion of household use of renewable energy as a substitute to traditional energy sources	
	[Minimize environmental impacts attributed to the energy sector]	Control traditional energy demand with increased use of improved cookstoves	
	[Minimize environmental impacts attributed to the energy sector] [Minimize adverse health impacts attributed to the energy sector] [Increase Access to Modern Energy]	Popularize use of gas for cooking in urban areas	
	[Minimize environmental impacts attributed to the energy sector] [Increase Security of Energy Supply]	Develop and promote greater use of Renewable Energies	
	Improve institutional and regulatory management of energy sources and governance in the energy sector		
D10	Expand access to improved energy services (and improve energy supply reliability)		1 objective separated here into 2 (Expand access to improved energy services and improve energy supply reliability)
	Improve energy supply reliability		
	Improve energy sector governance and regulation		
	Reduce health and environmental costs associated with energy supply and use		Mix of 2 or possibly 3 fundamental objectives. [Minimize environmental impacts attributed to the energy sector] [Minimize adverse health

Table A1 (*continued*)

Document	**Fundamental objectives [*Authors' addition, in absence of fundamental objective*]**	**Means objectives**	**Comments**
			effects attributed to the energy sector] or *environmental refers to both [decrease impact on climate change attributed to energy sector] and [decrease deforestation attributed to energy sector]*
	[Improve governance of the energy sector]	To enhance women's participation in energy policy planning formulation implementation and monitoring	
D11	*[Increase security of energy supply]*	Provide insights on the relative effectiveness and costs of generic policy options to increase the share of renewable sources in the primary energy mix	
D12	[Increase system reliability] [Improve ability to provide affordable energy]	Ensure in the medium and long term an optimal electricity supply, reliable and at an affordable cost to the population of the various Member States (WAPP objectives)	Both "ensure" and "optimal" are not explicit and difficult to quantify and control
D13	*[Minimize environmental impacts attributed to the energy sector] [Increase security of energy supply]*	articulate a national vision, targets and a roadmap for addressing key development challenges facing Nigeria through the accelerated development and exploitation of renewable energy	
	[Increase access to modern energy]	Expanding access to energy services and reducing poverty, especially in the rural areas	Mix of two objectives, where reducing poverty is also a fundamental objective, but not energy sector specific.
	Stimulating economic growth, employment and empowerment		
	[Improve quality of life of populations] [Decrease rural emigration]	Increasing the scope and quality of rural services, including, schools, health services, water supply, information, entertainment and stemming the migration to urban areas	"scope" is not explicit and difficult to quantify and control. Combination of multiple objectives
	[Minimize environmental impacts attributed to the energy sector] [Minimize adverse health effects attributed to the energy sector]	Reducing environmental degradation and health risks, particularly to vulnerable groups such as women and children	
	[Minimize environmental impacts attributed to the energy sector] [Increase Security of Energy Supply]	Improving learning, capacity-building, research and development on various renewable energy technologies in the country	
	[Increase Security of Energy Supply]	Providing a road map for achieving a substantial share of the national energy supply mix through renewable energy, thereby facilitating the achievement of an optimal energy mix.	"optimal" is not explicit and difficult to quantify and control
D14	*[Minimize environmental impacts attributed to the energy sector] [Increase Security of Energy Supply]*	Increase the share of renewable sources in the primary energy mix	
D15	*[Minimize environmental impacts attributed to the energy sector]*	Promote energy efficiency	
	[Increase system reliability]	Provide abundant energy	This was 1 objective separated here into 3 (Produce Abundant Quality and Cheap Energy)
	[Increase system reliability]	Provide quality Energy	
	Provide cheap Energy		"cheap" here assumed to mean *affordable*
	[Increase economic development]	Develop a policy of conquering the market (Market of electrical energy exchanges on inter-country connections)	

from developed countries rather than going through a complete bottom-up process of identifying the fundamental objectives for each EP activity.

Regarding indicators and attributes, there were few similarities found between the indicators or attributes employed and the indicators previously proposed for use in local planning activities of developed countries. This may represent some specificity of these indicators to developed countries, but it also may represent a gap in the planning activities of the ECOWAS region. Attributes such as "new connections to the grid", "trend in marginal costs of electricity" and "capacity to maintain and operate new technologies" can be pointed out as evidence that there is some specificity of attributes and indicators to regional objectives.

Recommendations:

- Identify whether additional objectives exist such as the "local "implementability" or "maintainability" which may aid in ensuring that the plans resulting from EP activities are successfully implemented. This would be a potentially beneficial step to achieving the ambitious goals that have been set in the region for increased modern energy access among others.

As a final remark, it should be noted that, despite the methodology adopted allowing for conclusions to only be drawn for ECOWAS member states, it is considered likely that the findings for the ECOWAS could be representative of other developing countries/regions as well.

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Appendix A. EP objectives

Table A1 presents the explicitly stated fundamental and means objectives from the reviewed EP documents. Where a means objective was stated an effort was made to establish the fundamental objective which was implied through this means objective.

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